JRSR 6 (2019) 153-159

Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

The Effect of Eight-Week Swiss Ball Training on the Integration of Functional Movements and Balance of Teenage Badminton Players

Ali Asghar Saberian Amirkolaei[1*], MSc; Ramin Balouchy[1], PhD; Rahman Sheikhhoseini[1], PhD

[1]Department of Sports Pathology and Corrective Exercises, Faculty of Physical Education and Sport Sciences, Allameh Tabataba'i University, Tehran, Iran

ARTICLE INFO

Article History:
Received: 06/05/2019
Revised: 10/06/2019
Accepted: 23/06/2019

Keywords:
Athletes
Racquet sports
Lumbosacral region
Postural balance
Exercise

Please cite this article as: Saberian Amirkolaei AA, Balouchy R, Sheikhhoseini R. The Effect of Eight-Week Swiss Ball Training on the Integration of Functional Movements and Balance of Teenage Badminton Players. JRSR. 2019;6(4):153-159. doi:

ABSTRACT

Background: Although injuries are an inevitable part of sports, exercise as a tool to prevent sports-related injuries and their consequences has caught the attention of many researchers in recent years. The present study aims to evaluate the effect of 8 weeks of Swiss ball training on the integration of functional movement of teenage badminton players and their balance.
Methods: This is a semi-experimental research. A total of 29 teenage badminton players were selected and divided randomly into control (n=13) and experimental groups (n=16). The experimental group performed an eight-week-long period of Swiss ball training that was recommended by the Badminton World Federation before participating in the badminton exercise sessions (3 sessions per week). Before initiation, after the completion of the fourth and eighth week of trainings, both groups underwent Y balance and FMS tests.
Results: Research findings indicated that eight weeks of Swiss ball training influenced FMS test ($P \leq 0.001$), lower limb Y balance test ($P \leq 0.001$), and upper limb Y balance test ($P \leq 0.001$) on the teenage badminton players. The post hoc testing identified a significant increase between weeks 4 and 8 in FMS tests ($P \leq 0.001$), lower limb Y balance test ($P \leq 0.001$) and upper limb Y balance test ($P \leq 0.001$).
Conclusion: A period of 8 Weeks of Swiss ball training affects the integrity of functional movements and balance of teenage badminton players. Therefore, these protocols can be suggested for trainers and other related fields.

Introduction

Badminton is a popular sport in the world [1]. As estimated by Badminton World Federation, about 150 million individuals play this sport across the world, and over 2000 players participate in international tournaments [1]. The badminton-related injuries account for 1-5 percent of total sports injuries [2]. The injury during physical activities is a serious problem of the sport [3]. Increased sports participation of teenagers since early ages as well as their sudden growth and mutation cause concerns over the risk and severity of the injury among them [4]. With increased participation in sport activities, the number of athletes vulnerable to the injury is also increasing. The damage occurs at a rate of 2.9 injuries for each player per 1000 hours playing badminton [5].

Swiss ball exercises are almost identical to the exercises with body weight, aside from the fact that they are slightly harder such that the unstable surface of Swiss balls are effective in improving the stability and strength of stabilizing muscles [6].

Exercise as a tool to prevent sports injuries is of great interest in today's rehabilitation actions [3]. The lack of awareness of coaches and athletes for preventing sports

Corresponding author: Ali Asghar Saberian Amirkolaei, Faculty of Physical Education and Sport Sciences, Allameh Tabataba'i University, Tehran, Iran. **Tel:** +98 9112131521;
Email: aa_saberian@yahoo.com

injury has made some talented athletes quit as a result of injuries [7]. Sports injuries have different causes, namely improper methods of performing techniques, repetitive movements, and non-stop hard exercises [8]. Balance is a critical factor which is necessary for any type of sport for correctly performing the techniques [9].

Considering the high frequency of sports injuries, pre-seasonal screening is vital in athletes nowadays. Screening is conducted for preventing injuries and improving functional techniques [10]. Cook et al. introduced functional movement screen tests (FMS) based on pre-seasonal screening and implementation-related factors [11]. The studies on the relationship between FMS and occurrence of injuries implied that FMS scores can predict injury occurrence. It was reported in another study that the application of preventive exercises among the individuals with scores below 14 in FMS reduced the occurrence of injuries [12]. Research on the professional football players also indicated that the athletes with scores below 14 in FMS are 6 times more vulnerable to injury, and they are more vulnerable to severe injuries by 51 percent [13]. In addition, in a study on the female student-athletes, it was shown that the female athletes with scores below 14 in FMS are four times more vulnerable to injury [10]. In other studies on the relationship between Y balance test and injury occurrence, prediction of Y test scores and injury occurrence has been addressed. McGuine et al. reported that balance of basketball players at the beginning of the season might predict the frequency of ankle injuries and the players with weaker balance are seven times more vulnerable to injury compared to the players with good balance [14]. Plisky et al. performed star balance test and reported that the difference of 4 cm in the anterior direction of two organs increased the likelihood of lower limb injury by 250%, and the total achievement rates of less than 94 percent for the limb length increased the likelihood of lower limb injury by 650% [15].

In sum, damage-induced financial problems (e.g. costs of surgery and rehabilitation and social-mental factors) seem to highlight the necessity of employing damage-preventive programs [16]. The preventive injury programs have been recently developed as an action for dealing with sport injuries [16]. However, no systematic injury prevention program has been formulated for badminton players [5]. Considering the positive effect of various exercises on scores of FMS test and Y balance test and since these tests are applicable to diagnosing and preventing sports injuries, they play an important role in the health of athletes.

To the best of authors' knowledge, no research has been carried out on the impact of Swiss ball exercises, provided by the Badminton World Federation in September 2013 for world-class II coaches, on the FMS and Y test Scores among badminton players [6]. Thus, the present study aims to determine whether the eight weeks of Swiss ball training can improve the test scores and, in turn, positively affect the integrity of functional movements and balance of athletes.

Methods

Participants

Current research is a semi-experimental. The population of this study included all male athletes in the badminton field in "Babol" city, Iran. 11 to 16 year-old badminton players were randomly selected, who exercised at least three times per week. The research ethics certificate for this study was obtained from the Graduate Council of the Faculty of Physical Education and Sport Sciences of Allameh Tabataba'i University. All of them were briefed about the research and their parents filled the informed consent form for participation in the research. The players had no special medical conditions, namely cardiovascular disease, weakness of the postural, vestibular disorders, and vision weakness, which might hinder their participation in the research. The players who suffered from injuries preventing them from attending the exercises or a match during the past 30 days or those with a recent history of surgery limiting their presence were excluded. Using the data provided by "Siamaki" et al. [17], considering $\alpha=0.05$, the test power of 80%, and the effect size of 0.71 for changing the FMS score in the experiment group before and after the exercise and assuming the use of the dependent t-test on G * Power software version 3.1, the sample size was estimated to be 14 individuals per group. Nevertheless, the required samples were set at 17 individuals per group according to probable withdrawals. During the research, one individual in the experiment group refused to participate in the exercise and four of the individuals in the control group withdrew due to injury and personal reasons. Subjects were randomly assigned to two experiment and control groups. Subsequently, all subjects participated in the pre-test (FMS and Y Balance upper and lower extremities tests). Afterwards, the control group subjects continued conventional badminton exercises without any additional training, as provided by the researcher, while the experiment group received 8-week (3 sessions per week) sessions of exercises where each session lasted for about 25 minutes under the direct supervision of the researcher. They took part in the Swiss ball training program that was included in the warm-up when the subjects in the experiment group were asked to participate in the conventional badminton exercises in addition to the research exercises, and not to participate in any other sport activity. Of course, according to the program, the overall total time allocated to the exercises and activities in both groups was the same. The subjects could not be absent over two consecutive sessions and they had to take part in at least 21 sessions, otherwise they would be excluded. Following the completion of the fourth and eighth weeks of the exercise program, all subjects took part in the post-test. In addition, the weight and height of the subjects were measured in pre-test using a measuring tape attached on the wall and digital scale.

Test Procedures

FMS Test: FMS tests include 7 movement tests and 3 clearing tests that can identify the limitations and changes in the natural movement patterns. This test kit is performed within 5-10 minutes, which includes deep squat, hurdle step, inline lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability tests [18] (Figure 1). The assessment is based on qualitative analysis through the four-point scoring system (0 to 3), so that 0 reflects the state with pain and 3 represents the correct implementation of the test [11]. The final FMS score ranges between 0-21, and average to high reliability levels have been reported in various studies among trained and non-trained subjects [19]. According to the research reports, a score below 14 makes the individual vulnerable to the injury [10]. The subjects received the verbal instructions, described by Cook et al. by the researcher [11].

Lower Limb Y Balance Test: In order to perform the test, the subject stands in the location specified by the test kit with the test leg and attempts to have the highest possible mobility with the other leg at Anterior, Posteromedial, and Posterolateral directions, while keeping his balance. The angle between posteromedial and posterolateral directions and the anterior direction is 135 degrees. At the time of reaching the highest trapping rate, the subject must touch the kit with the test leg very slowly and return to the initial state of the test.

Then, the total sum of the distance between the anterior, Posteromedial, and Posterolateral directions is divided by three times the length of the subject's foot, and it is then normalized by multiplying by 100. This obtained value is assumed as the subject's score. The length of the test leg is the distance between the anterior superior iliac spine (ASIS) and the medial malleolus, which is measured using a standard measuring tape while the subject is standing and the weight is evenly distributed between the two legs. A maximum of three trials is recorded as the subject's record in each of three directions. In addition, every subject exercised 4-6 times for each direction separately before the test [20].

Upper Limb Y Balance Test: In order to perform this test, the test subject's hand is placed in the center of the test area while in push-up mode, with a maximum distance of 30 cm between the legs. The subject maintains his balance while attempting to extend as much as possible with the other hand in the Medial, Inferolateral, and Superolateral directions. At the time of reaching the highest reach rate, the subject must push the kit with the test hand very slowly and return to the initial state of the test. Then, the total sum of the reach distance between the anterior, Inferolateral, and Superolateral directions is divided by three times the length of the subject's hand, and it is then multiplied by 100 for normalization; it is assumed as the subject's score. The length of the subject's hand is the distance from the seventh cervical vertebra to the most distal tip of the right middle finger, while the shoulder is in the 90-degree abduction mode with open elbows and wrists and fingers, which are evaluated using a standard measuring tape. The maximum three iterations are recorded as the subject's record for each direction. In addition, each subject exercises the three directions according to the test for learning before the test [21].

Swiss Ball Exercises: These exercises included 10 minutes of running and warm-up practices. Frequency of the exercise was three sessions per week for 8 weeks. The approximate duration of the exercises was about 25 minutes for each session. The severity of the exercises increased after the fourth week [25]. The subjects performed this exercise protocol in their warm-up program before starting the badminton exercises (Table 1). These exercises were designed based on the protocol provided by the Badminton World Federation [6] (Figure 2). This exercise protocol was adopted from the Woodward et al. and Sekendiz et al. included in the warm-up program of badminton players under the supervision of researcher [6, 22].

Statistical Analysis

Data related to the subjects' characteristics including age, weight, and height in addition to the research variables were analyzed using SPSS software version 23 (Table 2). Considering the normality of data and using the Shapiro-Wilk test, the analysis of variance (ANOVA) with repeated measures was performed for investigating

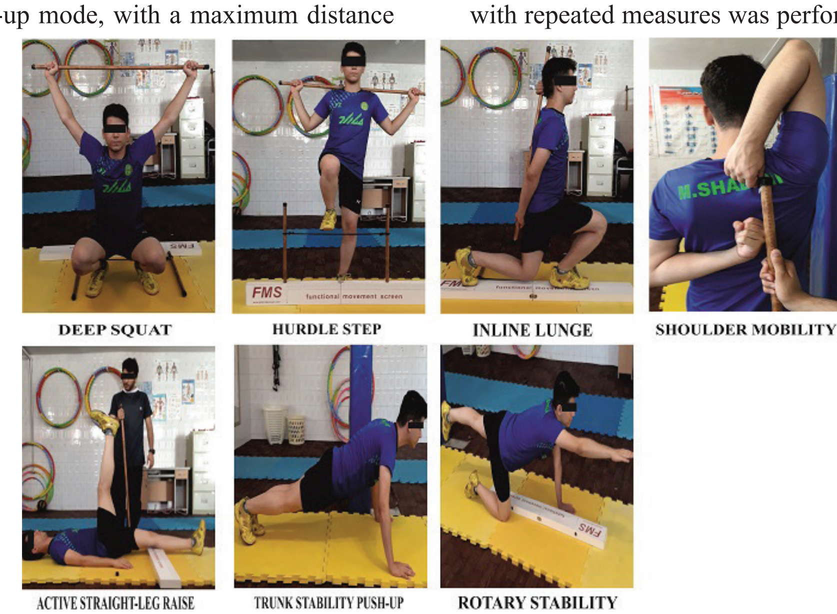

Figure 1: FMS Test

Table 1: Exercise protocol adopted from Woodward and Sekendiz et al. [6, 22].

	Exercise name	Exercise set
1	Warm Up	10 min
2	Roll Away	At first four weeks: 3 sets 10 times - at final four weeks: 3 sets 12 times
3	Reverse Bridge	At first four weeks: 2 sets until the hips starts falling - at final four weeks: 3 sets until the hips starts falling
4	Side Curl	For each side of body: At first four weeks: 10 sets 10 iterations - at final four weeks: 3 sets 12 iterations
5	Plank	At first four weeks: 2 sets until the pelvis starts falling - at final four weeks: 3 sets until the pelvic begin falling
6	Hamstring Curl	At first four weeks: 10 sets 10 iterations - at final four weeks: 3 sets 12 iterations
7	Press Up	At first four weeks: 10 sets 10 iterations - at final four weeks: 3 sets 12 iterations
8	Back Extension	At first four weeks: 10 sets 10 iterations - at final four weeks: 3 sets 12 iterations
9	Reverse Plank	At first four weeks: 2 sets until the pelvis starts falling - at final four weeks: 3 sets until the pelvic starts falling

Table 2: Anthropometric characteristics of subjects (Mean±SD)

Group	Age (year)	Height (cm)	Weight (kg)	BMI
Experimental group	13.31±1.2	160.25±12.39	56.28±13.98	21.87±3.78
Control group	12.31±1.32	149.15±12.23	43.15±12.19	19.13±2.99

Figure 2: Exercise protocol with Swiss ball

the variables among the research groups. In addition, the significance level was set at P<0.05.

Results

The demographic findings of the study are summarized in Table 2.

The findings obtained from a repeated measures ANOVA with a Sphericity Assumed correction for FMS and Lower Limb Y Balance tests and a Huynh-Feldt correction for Upper limb Y Balance test determined that mean FMS test [$F_{(2, 21.595)}=31.308$, P≤0.001] , Lower Limb Y Balance test [$F_{(2, 102.302)}=22.393$, P≤0.001], and Upper limb Y Balance [$F_{(1.771, 126.954)}=11.382$, P≤0.001] statistically differed between time points in a significant manner (Table 3).

A post hoc Bonferroni test revealed a significant increase between weeks 0 and 8 in the experimental groups' FMS tests (11.62±1.93 vs. 16.44±2.13, P≤0.001), lower limb Y balance test (84.02±7.43 vs. 96.26±7.05, P≤0.001), and upper limb Y balance test (71.83±11.36 vs. 85.15±8.86, P≤0.001). In addition, for the experimental group, the post hoc testing identified a significant increase between weeks 0 and 4 in FMS tests (11.62±1.93 vs. 14.5±1.89, P≤0.001), lower limb Y balance test (84.02±7.43 vs. 90.25±7.27, P≤0.001), and upper limb Y balance test (71.83±11.36 vs. 80.17±9.26, P≤0.001). Moreover, it recognized a significant increase between weeks 4 and 8 in FMS (71.83±11.36 vs. 85.15±8.86, P≤0.001), lower limb Y balance test (90.25±7.27vs. 96.26±7.05, P≤0.001) and upper limb Y balance test (80.17±9.26 vs. 85.15±8.86, P≤0.001) (Table 4). This suggested that an 8-week Swiss ball training improved FMS test scores and Y Balance tests.

In order to determine the differences among groups over time, the time plot of the groups' progress was consulted. As can be observed in Figure 3, in all of the above-mentioned variables, the experiment group has a higher slope of the progress, implying the effectiveness of the presented exercises in these variables.

Table 3: Variance analysis test of iterative sizes for determining effectiveness of the exercise in the test scores

Variable	Group	Pretest	4 weeks After exercises	8 weeks After exercises	Sig.
FMS Test	Experimental	11.62±1.93	14.5±1.89	16.44±2.13	0.001*
	Control	11.54±1.33	12.33±1.36	12.92±1.44	
Lower Limb Y Balance Test (Percent)	Experimental	84.02±7.43	90.25±7.27	96.26±7.05	0.001*
	Control	84.49±7.62	85.35±8.33	89.46±7.62	
Upper Limb Y Balance Test (Percent)	Experimental	71.83±11.36	80.17±9.26	85.15±8.86	0.001*
	Control	71.97±11.14	74.15±10.8	77.9±10.15	

* is significant for values below 0.05

Table 4: Results of Bonferroni correction for analysis of Between-Group Mean differences

Variable	TIME		Mean Difference	Std. Error	Sig.	Confidence interval	
						Lower bound	Upper bound
FMS Test	1	2	-1.78	0.22	0.001*	-2.34	-1.23
		3	-3.10	0.24	0.001*	-3.72	-2.48
	2	3	-1.32	0.2	0.001*	-1.82	-.82
Lower Limb Y Balance Test	1	2	-3.55	0.56	0.001*	-4.97	-2.12
		3	-8.61	0.62	0.001*	-10.19	-7.04
	2	3	-5.07	0.51	0.001*	-6.36	-3.77
Upper Limb Y Balance Test	1	2	-5.26	1.00	0.001*	-7.82	-2.70
		3	-9.63	0.79	0.001*	-11.64	-7.61
	2	1	-4.36	0.66	0.001*	-6.05	-2.68

* is significant for values below 0.05

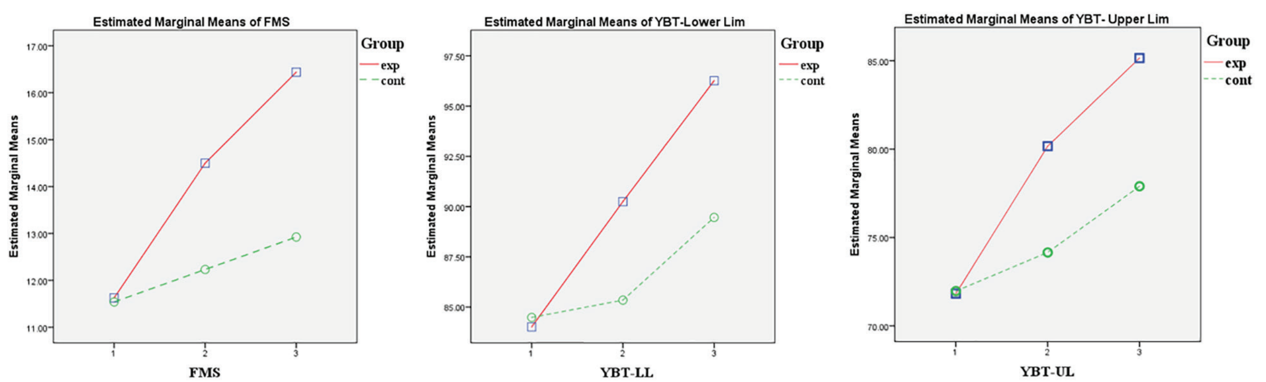

Figure 3: The time plot of the groups' progress to determine the differences among groups over time

Discussion

The purpose of this study was to evaluate the effect of eight-week Swiss ball training on the integrity of functional movements and balance in adolescent badminton players. The results demonstrated that the FMS and Y score of the experimental group's lower and upper limbs at the post-test stage are significantly different from those of the control group. These findings illustrated that the integrity of functional movements and balance were affected following eight weeks of Swiss ball training, which can play a central role in injury prevention among badminton players.

Frost et al. carried out a study on the relationship between FMS test scores and strength, power, aerobic capacity, maximization of performance and fitness. They found no significant relationship between the tests and FMS scores. However, the difference in the results could be attributed to the training variables and the design of the training protocol, as well as the age range of the subjects [23].

In this regard, Siamaki et al. showed that the basic maneuver patterns examined by the FMS improved in teenage soccer players following a functional practice intervention [17]. In the same case, Finch et al. (2015) considered the effect of neuromuscular exercises on preventing injury among football players [24]. Tabatabaei et al .concluded that compared to conventional training, neuromuscular exercises improved injury rehabilitation and FMS test scores for male basketball players prone to injury. The researchers concluded that the effectiveness of neuromuscular exercises was due to the emphasis of this training period on deep foot sensors and sense of balance, because the incidence of lesions in the lower limbs is greater in basketball players, especially in the ankle region [25]. Comparing the results of previous research with the results of the present study reveals that adaptive and neuromuscular control due to balanced and core exercises as a set can change the athlete's motor patterns and improve the FMS test scores.

Another research variable was balance studied by Sato and Mokha to assess the effect of core stabilization training on running, lower extremity stability, and a 5,000-meter running performance. They showed that significant advances were achieved in the 5,000-meter running and kinetic walking paths. However, no significant balance improvement was achieved, which is not consistent with the results of this study. The discrepancy may be due to the different training programs and the age of subjects since teens were growing and improving their motor skills within this period [26].

Johnson et al. suggested that core stabilization training can improve the deep sensory perception of the body, leading to balance enhancement. They investigated the effects of Pilates exercises, which were based on the strengthening of the trunk muscles, especially the lumbosacral region, on the dynamic balance of healthy people and showed that the balance improved, which is in agreement with the results of the present study [27]. Kahle and Gribble investigated the effect of 6 weeks of core stabilization exercises on the star test and demonstrated the positive effect of core muscle strength on dynamic balance [28]. Ali Khani et al. showed the positive effect of 8-week Swiss ball training on the dynamic balance of 12- to-15-year old footballers [29]. Cosio-Lima evaluated the effect of core stabilization exercises by the Swiss ball on the ground on the adjustment of the abdominal and back muscles and balance of females. Moreover, he argued that the group practicing with Swiss ball significantly improved the balance and electromyography of the abdominal and back muscles compared to the group on the ground. This can be attributed to the fact that the group exercising with the Swiss ball had higher nerve adaptation for abdominal muscles and their spinal cord opening, compared to the group exercising on the ground, to activate deep-seated sensations to reach balance. In this respect, the exercise with the Swiss ball showed short-term adjustment of the trunk muscles to achieve balance [30].

Furthermore, Sedaghati et al. emphasized the positive impact of core stabilization exercises on dynamic balance and performance of swimmers. They attributed the improvement of endurance and muscle strength in the core area to the enhancement of balance and performance of swimmers [31]. Furthermore, Harati et al. proposed core stabilization training to improve dynamic balance and performance of swimmers. They showed that 4-week core stabilization training improved upper and lower extremity balance of swimmers [32]. According to previous studies, it seems that the core muscle exercises in the central area of the body improve the balance of the lower and upper limbs. Also, poor central muscle interrupts energy transmission and, in turn, leads to decreased exercise performance and increased chances of injury, which is why central muscle strengthening has been suggested as a way to increase balance and training performance [33]. In the present study, the effect of Swiss ball training on functional integrity and balance was evident after statistical analysis. Although the control group, which participated only in routine badminton exercises, showed signs of improvements in all tests, they were not statistically significant. The results were indicative of significant improvements in all tests in the experimental group that used Swiss ball trainings in addition to routine badminton trainings.

Generalization of the research findings to the populations beyond the age range mentioned and to the female teenage badminton players is not appropriate. Moreover, the effect of these exercises on the performance and extent of athlete injuries in the long run is still ambiguous. Therefore, it is better to investigate the effects of Swiss ball exercises on other risk factors, as well as improving exercise performance among athletes of other sports or other ages. Another limitation of this research is the lack of accurate control of athletes' diet and lack of control of athletes' daily activity. It is suggested that these factors be taken into account in future research.

Conclusion

The results of this study revealed that eight weeks of Swiss ball training is effective in the integrity of functional movements and balance of upper and lower limbs of teenage badminton players. Thus, trainers and teachers can use the explained Swiss ball training to enhance the balance of teenagers, which leads to the improvement of their performance. Regarding the theoretical foundations, this performance advancement prevents athletes and teenage badminton players from falling, leading to a reduction in the probability of injuries. An effort to avoid injuries causes a decrease in direct and indirect costs of treatment on the one hand and yields an increase in the natural growth of bones and soft tissues by diminishing risk of falling and damages to growth plates on the other.

Acknowledgment

This research was conducted based on the secondary analysis and derived from the MA thesis in sports pathology and corrective exercises coded as 821/13253 approved by Allame Tabataba'i University in Tehran. Therefore, the author would like to thank the staff of Shahid Beheshti Sports Complex, Babol, Iran, for their contribution to prepare the test site.

Conflict of interest: None declared.

References

1. Arora M, Shetty SH, Khedekar RG, Kale S. Over half of badminton players suffer from shoulder pain: is impingement to blame? J Arthrosc Joint Surg. 2015;2(1):6-33.
2. Fahlstrom M, Bjornstig U, Lorentzon R. Acute badminton injuries. J Med Sci Sports. 1998;8(3):8-145.
3. Collopy KT, Friese G. High school sports injuries. Prehospital assessment and management of traumatic carotid artery dissection and mild traumatic brain injuries. J EMS magazine. 2010;39(9):5-60.
4. Caine D, Maffulli N, Caine C. Epidemiology of injury in child and adolescent sports: injury rates, risk factors, and prevention. Clin Sports Med. 2008;27(1):19-50.
5. Miyake E, Yatsunami M, Kurabayashi J, Teruya K, Sekine Y, Endo T, et al. A prospective epidemiological study of injuries in Japanese national tournament-level badminton players from junior high school to university. Asian J. Sports Med. 2016;7(1):e29637.

6. Woodward M. BWF Coach Education Level 2. 1th ed. Kuala Lumpur: Badminton World Federation; 2013. 247 p.
7. Chan K, Fu F, Leung L. Sports injuries survey on university students in Hong Kong.Br J Sports Med. 1984;18(3):195-202.
8. Shojaedin SS, Hadadnezhad M. Relationship Between Functional Movement Screen (FMS) Score And The History Of Injury And Identify The Predictive Value Of The FMS. J Res Rehabil Sci. 2013;9(3):69-459.
9. Ashton-Miller JA, Wojtys EM, Huston LJ, Fry-Welch D. Can proprioception really be improved by exercises? J Knee Surg. 2001;9(3):36-128.
10. Chorba RS, Chorba DJ, Bouillon LE, Overmyer CA, Landis JA. Use of a functional movement screening tool to determine injury risk in female collegiate athletes. J Sports Phys Ther. 2010;5(2):47-54.
11. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function–part 1. J Sports Phys Ther. 2006;1(2):62-72.
12. Peate W, Bates G, Lunda K, Francis S, Bellamy K. Core strength: a new model for injury prediction and prevention. J Occup Med Toxicol. 2007;2(1):3-12.
13. Schneiders AG, Davidsson Å, Hörman E, Sullivan SJ. Functional movement screenTM normative values in a young, active population. Int J. Sports Phys. Ther. 2011;6(2):75-82.
14. McGuine TA, Greene JJ, Best T, Leverson G. Balance as a predictor of ankle injuries in high school basketball players. Clin J Sport Med. 2000;10(4):44-239.
15. Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB. Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. J Orthop Sports Phys Ther.2006;36(12):9-911.
16. Junge A, Lamprecht M, Stamm H, Hasler H, Bizzini M, Tschopp M, et al. Countrywide campaign to prevent soccer injuries in Swiss amateur players. J Sports Med. 2011;39(1):57-63.
17. Siamaki R, Minoonejad H, Alizadeh MH, Soori R. Are Fundamental Movement Patterns Affected by Functional Training in Youth Male Soccer Players? J Res Rehabil Sci. 2017;13(1):7-13.
18. Sorenson EA. Functional movement screen as a predictor of injury in high school basketball athletes: Doctoral dissertation, University of Oregon; 2009.
19. Bishop C, Read P, Walker S, Turner AN. Assessing movement using a variety of screening tests. Strength Cond J. 2015(37):17-26.
20. Smith CA, Chimera NJ, Warren M. Association of y balance test reach asymmetry and injury in division I athletes. J Med Sci sports exerc. 2015;47(1):41-136.
21. Gorman PP, Butler RJ, Plisky PJ, Kiesel KB. Upper Quarter Y Balance Test: reliability and performance comparison between genders in active adults. J Strength Cond Res. 2012;26(11):8-3043.
22. Sekendiz B, Cug M, Korkusuz F. Effects of Swiss-ball core strength training on strength, endurance, flexibility, and balance in sedentary women. J Strength Cond Res. 2010;24(11):40-3032.
23. Frost DM, Beach TA, Callaghan JP, McGill SM. Using the Functional Movement Screen™ to evaluate the effectiveness of training. J Strength Cond Res. 2012;26(6):30-1062.
24. Finch CF, Twomey DM, Fortington LV, Doyle TL, Elliott BC, Akram M, et al. Preventing Australian football injuries with a targeted neuromuscular control exercise programme: comparative injury rates from a training intervention delivered in a clustered randomised controlled trial. J Inj Prev. 2016;22(2):8-123.
25. Tabatabaei H, Shojaedin SS, Ahmadi A, Hadadnezhad M. Effect of Six Weeks of Neuromuscular Warm Up Program on Injury Incidence and Functional Movement Screen Scores in Male Basketball Players Disposed to Injury. J Rehabil Med. 2018;6(4):192-200.
26. Sato K, Mokha M. Does core strength training influence running kinetics, lower-extremity stability, and 5000-M performance in runners? . J Strength Cond Res .2009;23(1):40-133.
27. Johnson EG, Larsen A, Ozawa H, Wilson CA, Kennedy KL. The effects of Pilates-based exercise on dynamic balance in healthy adults.J Bodyw Mov Ther. 2007;11(3):42-238.
28. Kahle NL, Gribble PA. Core stability training in dynamic balance testing among young, healthy adults. Athl Ther Today.2009;1(2):65-73.
29. Alikhani M, Norasteh AA, Ghorbani AH, Alikhani H, Mirzaaghajani A. The effect of 8 weeks of core stability training with Swiss ball on the balance in 12-15 year old soccer players. J Prac Stud Biosci Sport. 2014;2(3):47-59.
30. Cosio-Lima LM, Reynolds KL, Winter C, Paolone V, Jones MT. Effects of physioball and conventional floor exercises on early phase adaptations in back and abdominal core stability and balance in women. J Strength Cond Res. 2003;17(4):5-721.
31. Sedaghati P, Sarlak P, Saki F. The role of core stability training in dynamic balance and sport performance of girl child-age range competitive swimmers. J Sport Biomot Sci. 2018;17(1):9-10.
32. Harati J, Daneshmandi H, Shahabi Kaseb MR. Comparing the Effects of Dry-Land and In-Water Core Stability Training Programs on Swimmers' Upper Body Balance and Performance. J Sports Biomech. 2018;4(1):17-29.
33. Nesser TW, Huxel KC, Tincher JL, Okada T. The relationship between core stability and performance in division I football players. J Strength Cond Res. 2008;22(6):4-1750.